# AbstractID: 10158 Title: Dose perturbation and range shift with high-Z medium in proton beam

**Purpose:** Treatment planning for proton beams requires accurate CT numbers to correlate with electron densities that define the proton range. When high atomic number (Z) and high density materials (prosthesis) are present in the patient, they produce significant image artifacts leading to pronounced uncertainties in CT numbers that introduce unknown error in proton range estimations. We provide an analytical expression for range shift and its experimental verification along with measurement of the dose perturbation from high-Z media in a proton beam. **Materials and Methods:** An analytical expression is proposed for the range shift ($\Delta R$) in water for a high-Z material ($M$) of thickness, $t$ and density $\rho_M$, $\Delta R(t, Z_M) = t\rho_M \left(1.192 - 0.158\,\mathrm{Ln}\left(Z_M\right)\right)$. This expression was verified experimentally with various thicknesses and materials in a water phantom. The range shift was measured in a clinical proton beam having a range of 17 cm and a 10 cm SOBP for Z ranging from 13-82 (Al-Pb). Measurements were also made at the medium-to-water interface to evaluate dose perturbation using a thin window parallel plate ion chamber. **Results:** When materials were placed in the beam, the measured range shift was in good agreement with the theoretical calculation within ±2% standard deviation. The range shift is predominantly a function of physical density, stopping power ratio, and atomic number. Measured dose perturbation downstream of the material is less than +5% for thicknesses up to 30 g/cm$^2$. **Conclusions:** An experimentally verified analytical equation is proposed that establishes relation between the thickness of a high-Z material and the corresponding range shift in water. The dose perturbations are not pronounced (less than +5%) in proton beams. For clinical situations, the analytical expression could be used to verify the range shift and hence provide adequate margin for the target volume.